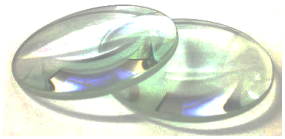
Thin lenses

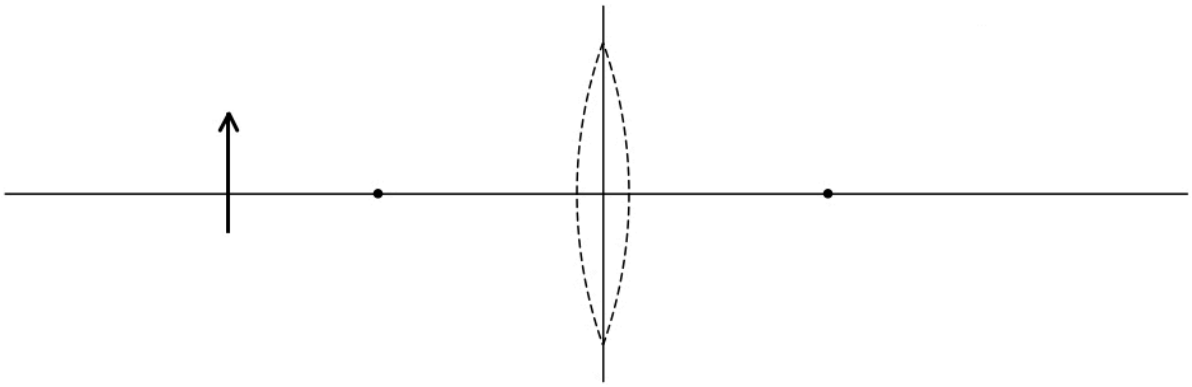
Converging lenses



A converging lens is a flat round piece of transparent material (usually glass), which is thicker at the middle than at the rim. The light rays passing through a converging lense are bent inward, that is, they converge.

1. Label the following concepts in the picture below:

Center of the lens: Point at the middle of the lens.
Principal axis: Horizontal line passing through the center of the lens
Center plane of the lens: Vertical line passing through the center of the lens
Focal point F (black round dots): Point where incident parallel light rays converge after passing through the lens (there are two!)
Focal length *f*: Distance from the center of the lens to its focal point



2. Go to

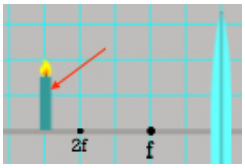
https://www.physicsclassroom.com/Physics-Interactives/Refraction-and-Lenses/Optics-Bench/Optics-Bench-Refraction-Interactive

Click the hot spot in the top left corner. The interactive opens in full screen mode (to exit later on, press the “esc” key).

a) Click the red buttons *Ray 1*, *Ray 2* and *Ray 3*. They’ll turn white.

b) Move the lever *H* for *height* until the Object Height reads approximately 20 cm

c) Grab the “candle” with the mouse and move it to the left until the Object Distance reads approximately 50 cm



3. Find the rules for ray tracing in thin converging lenses

a) Click the button *Ray 1* until it turns red. There's a red light ray travelling from the flame of the candle to the lens, where it is refracted, and then continues on the other side of the lens.
Change the object height by moving the lever *H* for *height* back and forth, and watch the refracted light ray closely.
Draw the path of the light ray into the picture on page 1, and complete the following sentence:

A light ray entering a converging lens parallel to its principal axis continues on exiting the lens

.....

b) Click the button *Ray 1* until it turns white. Then click *Ray 2* until it turns red. Again change the object height, and if you like, also the object distance (by grabbing the candle with the mouse and moving it). Watch the refracted light ray closely.
Draw the path of the light ray into the picture on page 1, and complete the following sentence:

A light ray passing through the focal point of a converging lens before entering it continues on exiting the lens

.....

c) Click the button *Ray 2* until it turns white. Then click *Ray 3* until it turns red. Again change the object height, and if you like, also the object distance (by grabbing the candle with the mouse and moving it). Watch the refracted light ray closely.
Draw the path of the light ray into the picture on page 1, and complete the following sentence:

A light ray passing through the center of a converging lens continues on exiting the lens

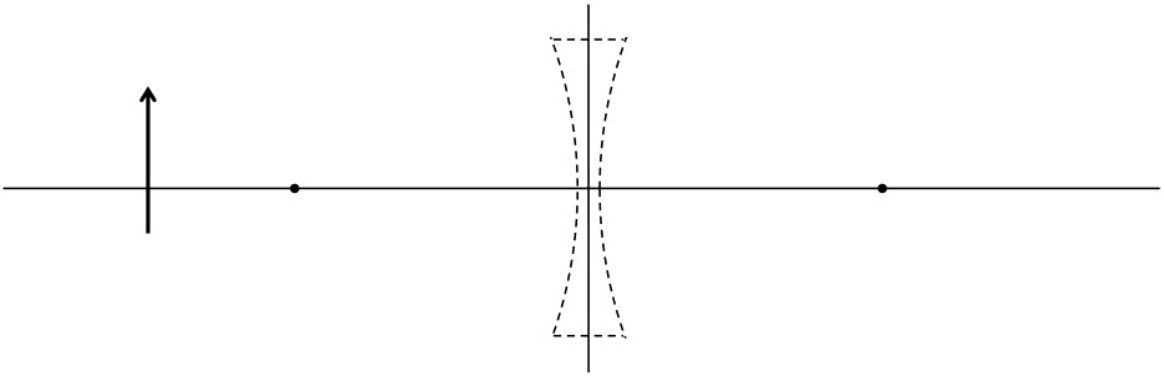
.....

Diverging lenses

A diverging lens is a flat round piece of transparent material (usually glass), which is thinner at the middle than at the rim. The light rays passing through a diverging lense are bent outward, that is, they diverge.

1. Label the following concepts in the picture below:

Center of the lens: Point at the middle of the lens.
Principal axis: Horizontal line passing through the center of the lens
Center plane of the lens: Vertical line passing through the center of the lens
Virtual focal point F' (black round dots): Incident parallel light rays diverge after passing through the lens. The virtual focal point is the point where they seem to come from.
Negative focal length –*f*: Distance from the center of the lens to its virtual focal point



2. Go to

https://www.physicsclassroom.com/Physics-Interactives/Refraction-and-Lenses/Optics-Bench/Optics-Bench-Refraction-Interactive

Click the hot spot in the top left corner. The interactive opens in full screen mode (to exit later on, press the "esc" key).

a) In the orange bar, on the right side, choose *Diverging*.

b) Again click the red buttons *Ray 1*, *Ray 2* and *Ray 3* to make them turn white.

c) Again move the lever *H* for *height* until the Object Height reads approximately 20 cm, and grab the "candle" with the mouse and move it to the left until the Object Distance reads approximately 50 cm

3. Find the rules for ray tracing in thin diverging lenses

a) Click the button *Ray 1* until it turns red. There's a red light ray travelling from the flame of the candle to the lens, where it is refracted, and then continues on the other side of the lens. The dotted line is not a light ray – it merely shows where the refracted light ray seems to come from as it exits the lens.
Change the object height by moving the lever *H* for *height* back and forth, and watch the refracted light ray closely.
Draw the path of the light ray into the picture on page 3, and complete the following sentence:

A light ray entering a diverging lens parallel to its principal axis continues on exiting the lens

.....

b) Click the button *Ray 1* until it turns white. Then click *Ray 2* until it turns red. Again change the object height, and if you like, also the object distance (by grabbing the candle with the mouse and moving it). Watch the refracted light ray closely.
Draw the path of the light ray into the picture on page 3, and complete the following sentence:

A light ray aiming at the virtual focal point on the other side of a diverging lens continues on exiting the lens

.....

c) Click the button *Ray 2* until it turns white. Then click *Ray 3* until it turns red. Again change the object height, and if you like, also the object distance (by grabbing the candle with the mouse and moving it). Watch the refracted light ray closely.
Draw the path of the light ray into the picture on page 3, and complete the following sentence:

A light ray passing through the center of a diverging lens continues on exiting the lens

Note: The rules for ray tracing found here only apply to *thin lenses*. Lenses have two surface and the light is refracted twice as it passes through the lens. In a thin lens however, we can pretend that the light rays are bent only once, at the center plane of the lens.